Schultz E.S 1944

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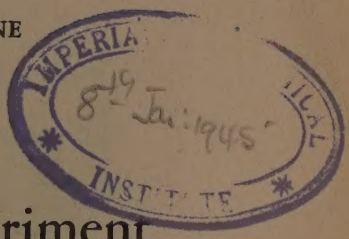

The Maine Agricultural Experiment Station

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BULLETIN 427 JULY, 1944

Early Harvesting of Healthy Seed Potatoes for the Control of Potato Diseases in Maine

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BULLETIN 427

EARLY HARVESTING OF HEALTHY SEED POTATOES FOR THE CONTROL OF POTATO DISEASES IN MAINE

E. S. Schultz,[1] Reiner Bonde,[2] and W. P. Raleigh[3]

INTRODUCTION

The State of Maine produces approximately 164,000 acres of potatoes annually. This acreage requires nearly 3,000,000 bushels of seed potatoes for planting. Such a large quantity of good seed is usually not readily available so that much inferior seed often is planted. Inferior seed potatoes give smaller yields and in addition decrease the quality of the crop because of net necrosis (caused by the leafroll virus in certain varieties), ring rot, or other diseases. Disease in seed potatoes is one of the most important problems that confront the potato growers of Maine. Often a grower or buyer purchases seed potatoes considered to be of high quality and finds later that they were badly diseased. The resulting crop is a disappointment and is injurious to our potato industry.

The problem of securing good seed potatoes has been especially acute in Maine since the serious leafroll epidemic of 1938 resulting from an unusual amount of spread of the disease in 1937. Since then the control of leafroll has been more difficult for the growers of certified seed potatoes, as well as for the growers of table stock. Other virus diseases have remained more or less important.

Shortly after the discovery about 25 years ago that virus diseases were important in potatoes, seed plots were started with the hope that they would give the greatest possible reduction in losses caused by virus diseases, including leafroll, mosaic, and spindle tuber. Seed plots have been found to vary in their effectiveness in virus-disease control, according to the degree of isolation from other

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potatoes, the amount of virus disease present, location, thoroughness and time of roguing, and earliness of planting (4, 5).

Progress in seed-plot methods has been recorded in a number of previous publications by Folsom and Schultz (6), Folsom, Schultz, and Bonde (7), Schultz, Bonde, and Raleigh (8), Simpson (11), Simpson, Libby, and Wyman (12), Folsom (5), and Simpson and Porter (13).

One phase of control that has recently assumed greater importance is "early harvesting." This consists of killing or removing the tops and digging the tubers early in the growing season before viruses that are introduced into the foliage by insects or other means have had time to reach the tubers. In early harvesting the grower may run into certain difficulties such as the lateness of ring-rot symptoms, the great amount of labor needed to pull the tops, and the danger of late-blight rot when late blight ("rust") is present on early-harvested plants.

This bulletin records some of the benefits derived from early harvesting and discusses some of the difficulties involved.

PRELIMINARY EXPERIMENTS ON THE SPREAD OF VIRUS DISEASES IN SEED STOCKS HARVESTED AT DIFFERENT DATES, 1925 TO 1927

Schultz and Folsom, working in Aroostook County, Maine, found in 1918 that less of the virus diseases was present in seed potatoes if they were harvested before aphids were abundant (*9*, p. 332). They also found in 1919 that the maximum amount of disease is avoided if the potatoes are dug within 10 days of the maximum infection by the transmitting insects (*10*, p. 97). Further studies in 1923 and 1924 showed that the greatest spread of the virus diseases occurred after the first week of August (*7*, tables 12 and 15).

During the years 1925 to 1927, inclusive, experiments were conducted in Aroostook County, Maine, to obtain additional information regarding the dates during the season when the virus diseases are spread most extensively. It was thought such data would indicate the time that commercial seed plots should be harvested to avoid becoming contaminated with the virus diseases that are disseminated by insects.

For this experiment, blocks of seed potatoes infected with mild mosaic, leafroll, and spindle tuber were planted in different parts of a field of healthy potatoes. Both the diseased and the healthy seed stocks used for this experiment were of the Green Mountain variety. At approximately 10-day intervals beginning August 1 tubers were harvested from the healthy plants by taking one tuber from a hill in the rows that were adjacent to rows with diseased plants. These were put into storage and planted the following spring to determine the extent to which they had become infected as a result of being exposed to the respective diseases. This procedure gave an index of the relative amount of virus-disease spread which had occurred at the different harvesting dates during 1925 to 1927.

The results of this experiment have been summarized in table 1. The data show that in most cases mild mosaic was absent from seed potatoes harvested before the tenth of August and that dissemination increased as the season progressed. Spindle tuber also was absent from seed stock harvested before the tenth of August. In 1925, however, spindle tuber did occur in the seed that had been harvested after August 10. In 1927, 2 per cent spindle tuber had been disseminated to the healthy plants dug at the time of the first killing frost. Leafroll was not disseminated during the 3-year period covered by this experiment.

EARLY-HARVEST SEED PLOTS ON AROOSTOOK FARM, PRESQUE ISLE, MAINE, 1935 TO 1943

In 1935 an experiment was begun to determine the extent to which different strains of seed potatoes could be maintained in a virus-free condition by careful roguing of the seed plot and then pulling the vines and harvesting the crop before aphids became abundant. A strain of Triumph and two strains of Green Mountain potatoes were used for this experiment. The seed plot was not well isolated, since it was only 200 to 1,000 feet from commercial fields infected with different virus diseases. The seed plot was planted by hand as early in the season as was possible, with early-harvested potatoes selected from the seed plot the previous season. The smallest tubers were planted whole and the larger ones were cut

and planted in tuber units.[4] When the plants were 3 to 6 inches tall, which was about the last week in June, and every week during July the seed plot was inspected for diseased plants. These were dug and, along with the seed pieces and new tubers, were placed at once in a close-mesh bag and removed from the plot.

TABLE 1

Mild Mosaic, Leafroll, and Spindle Tuber in Green Mountain Field-exposure Plots[1] harvested at different dates, Aroostook Farm, Presque Isle, Maine, 1925 to 1927

Dates harvested	Disease for different years[2]								
	1925			1926			1927		
	Mild mosaic	Leaf-roll	Spindle tuber	Mild mosaic	Leaf-roll	Spindle tuber	Mild mosaic	Leaf-roll	Spindle tuber
	%	%	%	%	%	%	%	%	%
August 1 to 10	0	0	0	0	0	0	4	0	0
August 11 to 20	15	0	7	9	0	0	36	0	0
August 21 to 30	30	0	11	34	0	0	46	0	0
August 31 to September 10	31	0	13	72	0	0	58	0	2
September 11 until killing frost	25	0	10	83	0	1	—	—	—

[1] Rows of healthy potato plants were grown adjacent to blocks of diseased plants in the same fields.

[2] Percentages based on plants grown from 100 tubers harvested at each of the different dates for the respective diseases. The tubers were planted the following year for determining the extent of virus-disease spread.

The potato tops in the seed plots were pulled by hand before aphids had appeared and begun to disseminate the virus diseases. The tops were pulled the last week of July or the first week of August or as near to this time as the conditions permitted. Hills were dug and kept separate and the following year planted as hill units. If any plant in a hill unit showed disease the entire unit was discarded.

The data secured from this experiment are recorded in tables 2, 3, and 4. Table 2 records the results obtained with the Triumph variety.

[4] Many small tubers result when the crop is harvested early in the season. Such tubers weighing about 1 ounce or less were planted without being cut. The larger tubers were cut into as many seed pieces as the size permitted, allowing approximately 1 to 2 ounces per seed piece.

It is very difficult to produce healthy Triumph seed potatoes in the concentrated potato area of Maine, because this variety is very susceptible to the virus diseases. The data in table 2, however, show that disease-free seed was produced in 6 of the 8 years that the experiment was conducted. In 1936 only 0.5 per cent mosaic was present and in 1937 only 2.9 per cent. In 1936 and 1937 a few aphids were observed in the seed plot at the time the potatoes were harvested. In 1937 a badly diseased commercial field was located approximately 200 feet away.

In only 1940 and 1941 were tubers harvested late in the season. Those harvested on September 20, 1940, had 48 per cent severe mosaic and 65 per cent leafroll, those harvested September 24, 1941, had no mosaic but had 44 per cent leafroll. These high disease percentages show that the virus diseases had been disseminated extensively the latter part of 1940 and 1941 and that the practice of harvesting the crop early while aphids were still few was of great benefit in controlling the spread of the diseases.

TABLE 2

Mosaic and Leafroll in the Triumph Variety Grown in Tuber-unit Seed Plots, Aroostook Farm, Presque Isle, Maine, 1935 to 1942

Year[1]	Date harvested	Hills in sample	Virus disease in sample
		Number	Per cent
1935	August 1	537	0.0
1936	August 7	187	.5
1937	August 7	174	2.9
1938	July 28	220	.0
1939	August 3	240	.0
1940	July 31	270	.0
1940	September 20[2]	200	48.0 mosaic 65.0 leafroll
1941	July 31	144	.0
1941	September 24[2]	100	44.0 leafroll
1942	July 25	144	.0

[1] The tubers were harvested on the given dates and planted the following year to determine the percentage of virus diseases.
[2] Harvest at time of killing frost.

Table 3 gives a summary of the amount of virus-disease spread that occurred in a Vermont strain of Green Mountain potatoes that was propagated in the experimental seed plot for the 9-year period 1935 to 1943.

TABLE 3

Mosaic and Leafroll in a Vermont Strain of Green Mountain Grown in Tuber-unit Seed Plots and Harvested at different dates, Aroostook Farm, Presque Isle, Maine, 1935 to 1943

Year[1]	Date harvested	Hills in sample	Disease in sample	
			Mosaic	Leafroll
		Number	Per cent	Per cent
1935	August 1	1,449	0.0	0.0
1936	August 7	1,443	.2	.0
1937	August 7	1,533	.5	.8
	August 13	100	4.0	1.0
	August 25	100	16.0	25.0
1938	July 27	1,246	.0	.0
1939	August 3	1,080	.0	.0
	August 13	100	.0	.0
	August 23	100	2.4	.0
	September 3	117	5.0	2.5
	September 29	116	6.8	1.7
1940	July 31	1,056	1.0	.0
	August 31	100	2.0	2.0
	September 11	100	.0	2.0
	September 20	100	72.0[2]	16.0
1941	July 31	1,080	.0	.0
	August 8	383	.0	3.0
	August 28	100	.0	15.0
	September 7	177	.0	22.0
	September 24	139	.0	31.0
1942	July 25	1,030	.0	.0
	August 5	197	.0	.0
	August 16	200	.0	.0
	August 27	190	3.7	2.6
	September 8	170	4.2	9.4
1943	August 6	300	.0	.0
	August 16	200	.0	.0
	August 28	100	.0	.0
	September 8	100	.0	1.0
	September 29	100	1.0	2.0

[1] The tubers were harvested on the dates indicated and planted the following year for determining the extent of virus-disease spread, except for the 1943 samples which were planted in a greenhouse.

[2] Mostly rugose mosaic caused by a combination of the X virus with the Y virus.

The data in table 3 show that the earliest date of harvest varied from July 25 to August 7 for the different years. This early harvesting prevented the spread of virus in 6 of the 9 years, and the spread was relatively slight in the other 3 years. For instance, in 1936 only 0.2 per cent of the early-harvested seed stock contained mild mosaic, and in 1937 0.5 per cent of that harvested on August 7 had contracted mild mosaic and 0.8 per cent had leafroll. In 1940

1 per cent of the stock harvested July 31 had mosaic. In 1940 a badly diseased field was located only 200 feet from the experimental seed plot, and aphids were present before the potatoes were dug, which no doubt accounts for the early spread.

It should be noted that there was no disease in the seed stock that was harvested as late as August 13, 1939, August 16, 1942, or August 28, 1943. In 1942 the virus diseases were present, however, in the August 27 harvest. The spread of virus diseases was relatively small in 1943 even when the seed stock was harvested as late as September 29.

The data show that there was little or no disease in a sample

TABLE 4

Mosaic and Leafroll in a Maine Strain of Green Mountain Potatoes Grown in Tuber-unit Seed Plots and Harvested at Different Dates, Aroostook Farm, Presque Isle, Maine, 1935 to 1943

Year[1]	Date harvested	Hills in sample	Disease in sample	
			Mosaic	Leafroll
		Number	Per cent	Per cent
1935	August 1	1,210	0.00	0.0
1936	August 7	1,026	.00	.0
1937	August 7	1,023	1.60	.5
1938	July 28	914	.00	.0
1939	August 3	1,218	.00	.0
	August 13	200	.00	.5
	August 23	200	.00	1.5
	September 3	108	2.70	.0
	September 29	100	2.60	.0
1940	July 31	1,290	.08	.0
	September 20	100	35.00[2]	33.0
1941	July 31	1,380	.00	.0
	August 8	440	.00	.9
	August 28	100	2.00	10.0
	September 7	100	5.00	20.0
	September 24	100	20.00	30.0
1942	July 25	1,521	.00	.0
	August 5	440	.00	.0
	August 20	100	2.00	10.0
1943	August 6	100	.00	.0
	August 16	100	.00	.0
	August 28	100	1.00	.0
	September 8	100	1.00	.0
	September 29	100	1.00	2.0

[1] The tubers were harvested on the dates indicated and planted the following year for determining the extent of virus-disease spread.
[2] Mostly rugose mosaic caused by a combination of the X virus with the Y virus.

if it was harvested by the first week of August; that the amount of virus disease increased as the season progressed; and that by late August and during September stocks were in most cases badly infected.

Table 4 shows the percentage of mosaic and leafroll that was present in another strain of Green Mountain potatoes when harvested at different dates. The data show that mosaic and leafroll were absent in the early-harvested crop in 7 of the 9 years included in the experiment.

In 1937, when a diseased commercial field was only 200 feet away, the seed stock harvested on August 7 had 1.6 per cent mosaic and 0.5 per cent leafroll. In 1940 when a field of diseased potatoes was nearby, the seed stock harvested on July 31 had 0.8 per cent mosaic but no leafroll.

Seed potatoes were harvested in the experimental seed plot at two or more successive dates during the years 1939 to 1943, inclusive. Here again the percentage of virus disease in the seed stock increased as the season progressed. In 1940 the July 31 harvest had only 0.08 per cent virus disease but the September 20 harvest had 35 per cent mosaic and 33 per cent leafroll. In 1941 the July 31 harvest had no mosaic or leafroll, the August 8 harvest had only 0.9 per cent leafroll, but the September 24 harvest had 20 per cent mosaic and 30 per cent leafroll.

In 1943 aphids were not very abundant. By August 16 mosaic and leafroll had not spread into the early-harvested seed plot, by August 28 and September 8 only 1 per cent mosaic was present, and by September 29, 1 per cent mosaic and 2 per cent leafroll were present. The data for 1943 show that in years when aphids are few harvest may be delayed until the middle of August.

TRIALS OF EARLY HARVESTING CONDUCTED IN COOPERATION WITH FARMERS

Experimental Seed Plots

The question naturally arose as to whether the favorable results obtained by the early-harvesting method on Aroostook Farm also could be obtained on other farms in Maine. Early-harvest seed plots were established in cooperation with farmers

located in eight different localities and, with one exception, were not well isolated. Under the supervision of the Maine Agricultural Experiment Station[5] they were planted, rogued, and harvested in general accordance with the methods described in the later section on recommendations. Early harvesting was done between July 25 and August 5 and late harvesting after killing frost. In table 5 the results obtained from these seed plots are recorded.

The data in table 5 show that in all cases early harvesting reduced materially the amount of disease. In no instance did the early-harvested seed potatoes have more than a total of 1.6 per cent virus disease. Twenty-one seed plots were conducted during the 4-year period, and in all cases the early-harvested seed potatoes harbored considerably less disease than the late-harvested. Mosaic and leafroll were entirely eliminated in 13 of the 21 seed plots, and the total amount of virus disease in the others was relatively small, varying from 0.2 to 1.6 per cent.

TABLE 5

Virus Disease in Green Mountain Seed Stocks Produced in Different Localities by the Early-Harvest Seed-Plot Method, 1934 to 1937

Location	Disease in seed stocks for different years[1]							
	1934		1935		1936		1937	
	Early harvest[2]	Late harvest[3]	Early harvest[2]	Late harvest[3]	Early harvest[2]	Late harvest[3]	Early harvest[2]	Late harvest[3]
	%	%	%	%	%	%	%	%
Masardis	0.0	0.4	0.0	0.5	0.0	0.0	0.0	0.0
New Canada	—	—	.0	2.6	.2	1.0	0.5	3.0
New Sweden	—	—	.9	8.0	.0	2.3	—	—
Presque Isle	.6	4.0	.0	2.4	.0	.8	.0	4.0
Sherman Mills	.0	2.1	.0	.2	—	—	—	—
Smyrna Mills	1.6	6.0	1.5	7.6	—	—	—	—
Spaulding	—	—	.9	1.7	.0	.0	.5	1.0
Winterville	—	—	.0	2.4	—	—	—	—

[1] Includes mosaic and leafroll.
[2] Early harvesting was done between July 25 and August 5.
[3] "Late harvest" refers to harvests made after the time of killing frost.

FARMERS' SEED PLOTS

It was considered by many that the production of good seed potatoes by the early-harvesting method would not be practical

[5] Supervised by W. F. Porter, G. W. Simpson, and Reiner Bonde.

and, therefore, would not be adopted by the farmers.

A number of farmers in Maine, however, now make a practice of early harvesting enough seed potatoes each year to plant their seed plots the coming year. Some farmers have been so successful in growing good seed by this method that they now plant most of their acreage with such seed. Some have produced high-quality seed stocks for the past 10 to 15 years with no losses from leafroll, mosaic, spindle tuber, or ring rot.

CONTROL OF RING ROT IN EARLY-HARVEST SEED PLOTS

Any good seed-improvement program for Maine must take into consideration the control of ring rot. Unfortunately this disease often is not readily detected at the time the early-harvested seed plot is dug. Studies have shown, however, that a seed stock was nevertheless easily maintained free from this disease, provided the initial stock was free from ring rot and precautions were taken thereafter to prevent it from becoming contaminated.

In the experiments reported here one strain of Triumph and two strains of Green Mountain have been propagated free from ring-rot infection since 1935 on Aroostook Farm where the tests with ring rot were also made. It should be mentioned also that ring rot was absent in the potatoes grown on the farmers' early-harvested seed plots previously referred to in this bulletin.

Furthermore, certain growers have maintained the same seed stock free from ring rot and with a minimum amount of virus diseases for nearly 20 years, because their seed potatoes were free from ring rot when their seed-plot program was begun, and they permitted no seed stocks that were infected to be brought to their farms. The spread of the virus diseases was controlled by adopting the early-harvesting methods. More detailed information regarding ring rot is available in Maine Agricultural Experiment Station Bulletin 396 and Maine Agricultural Extension Bulletin 286 (*1, 3*).

KILLING TOPS WITH WEED-KILLING PRODUCTS FOLLOWED BY HARVESTING WITH MACHINE

The potato vines of the early-harvested seed plots, to which reference has been made previously in this bulletin, were pulled by hand. This method of destroying the tops is very tedious, time-consuming, and expensive and therefore has not been adopted by many farmers. Many more growers would conduct early-harvested seed plots if an easy and economical method were available for killing the potato tops.

Some growers have attempted to harvest their seed plots by the use of machine diggers while the tops were still green in order to overcome the problem of pulling the tops. This method is very precarious, however, because a large part of the crop may be lost from late-blight tuber rot if the plants have even a trace of late blight or "rust" on the foliage.

In 1940 two commercial growers who dug their seed plots while the tops were green experienced no loss from late-blight rot, and the potatoes kept well in storage. In 1941, however, they lost most of their early-harvested seed potatoes because the plots were dug while the foliage was green and slightly infected with late blight. In 1943 approximately 50 per cent of the tubers from another seed plot decayed because they were dug while the foliage was infected with late blight. Farmers, therefore, are warned not to harvest their potato crop until the plants are dead and there is no danger of contaminating the potato tubers with the late-blight organism.

Spraying with a solution of sulfuric acid has been successfully used in Europe to kill potato tops and to hasten the maturity of the tubers. A sulfuric acid solution of approximately 6 to 7 per cent by weight was found to be effective (*2*, pp. 173-175), but is very toxic and dangerous to handle and therefore its use has not been recommended in Maine.

A concentrated copper sulphate solution (35 pounds in 100 gallons of water) when applied with a horse-drawn wheel-traction sprayer did not kill potato foliage sufficiently in 1935 and 1936 to recommend it for killing tops on the early-harvested seed plots. It is used by some growers, however, for spraying partially green potato fields just prior to harvesting the crop, the claim being made that this practice eliminates late-blight tuber decay.

Sinox[6] and Elgetol[6] when used at concentrations of 1 gallon in 100 gallons of water only partly killed potato tops in preliminary experiments conducted in 1941.

The following materials and formulas were used in experiments for killing potato tops on Aroostook Farm in 1943:

1. Sinox[7] (2 gallons) and ammonium sulfate (10 pounds) in 100 gallons of water; applied at the rate of about 135 gallons per acre.
2. Handy Killer,[8] 4 pints per 100 gallons of water; applied at the rate of about 135 gallons per acre.

Both of these preparations killed Green Mountain potato tops satisfactorily. Handy Killer acted somewhat more slowly than Sinox but was satisfactory. Some commercial growers also claim good results with the Handy Killer solution. Sinox with ammonium sulfate killed the tops quite rapidly, dying becoming evident a few hours after the material had been applied.

TREATING FRESHLY DUG POTATO TUBERS FOR THE CONTROL OF LATE-BLIGHT DECAY OF TUBERS

It has been shown previously in this bulletin that there is great risk of the tubers rotting in storage when harvested while the foliage is still green, if late blight is present. An experiment was, therefore, conducted for the purpose of determining whether it is possible to reduce the amount of late-blight tuber decay by killing the tops before harvest or by treating the freshly dug tubers with certain disinfectants.

The foliage of a Green Mountain potato field was permitted to become infected with late blight or "rust." A part of this field was then sprayed twice with a Sinox and ammonium sulfate solution in order to kill the tops and destroy the late-blight fungus. Parts of the same field were not sprayed. An early and a late

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[6] Manufactured by Standard Chemical Products, Inc., Hoboken, N. J.

[7] The active ingredient in Sinox is said to be the sodium salt of dinitro-ortho-cresol.

[8] A sodium arsenite liquid product sold locally as a "bug" poison and for the purpose of killing potato tops.

harvest were made of both the sprayed and unsprayed plots. The early harvest was made with a tractor-powered machine 2 days after the Sinox and ammonium sulfate spray had been applied.

The freshly dug tubers were picked into wooden slatted crates and treated immediately in the field by the instant dip method or for 5-minute periods in a formaldehyde solution (1 pint in 30 gallons of water) and a weak Bordeaux mixture (3-3-100). Each treatment was replicated five times, each lot consisting of approximately 50 pounds of tubers. The treated potatoes, as well as the untreated, were stored immediately in crates in an ordinary bin until they were examined 6 weeks later for late-blight decay.

The results of this experiment, recorded in table 6, show that approximately 37 per cent of the freshly dug tubers rotted in storage when neither the foliage was killed by the Sinox-ammonium sulfate spray nor the tubers treated with a disinfectant. Nearly 13 per cent of the tubers decayed when the tops were killed but the freshly dug tubers were not treated. The tops were not entirely dead at the time of harvest, and it seems possible that some late-blight spores were still viable which infected the tubers while they were being dug. The fact that 2.59 per cent of the crop decayed in the case of the plots on which the tops were killed and the crop dug late would indicate that some infection had occurred before the tops were killed.

TABLE 6

Effectiveness of Killing Potato Foliage and Treating Freshly Dug Seed Potatoes in Controlling Late-blight Tuber Decay

Treatment of potato foliage	Time of harvest	Treatment of tubers		Percentage of tubers with late blight rot
		Material	Length of time	
				Per cent
Sprayed with Sinox[1]	Early	Formaldehyde[2]	Instant dip	3.54 ± 0.65
Do	do	do	5 minutes	4.70 ± .68
Do	do	Bordeaux mixture[3]	Instant dip	5.85 ± .55
Do	do	do	5 minutes	8.99 ± 1.35
Do	do	----------	----------	12.89 ± .93
Do	Late	----------	----------	2.59 ± .69
Not sprayed	Early	Formaldehyde[2]	Instant dip	2.59 ± .72
Do	do	do	5 minutes	2.26 ± .36
Do	do	Bordeaux mixture[3]	Instant dip	4.45 ± .40
Do	do	do	5 minutes	4.77 ± .41
Do	do	----------	----------	37.20 ± 4.29
Do	Late	----------	----------	5.87 ± .56

[1] Manufactured by Standard Chemical Products, Inc., Hoboken, N. J. Used at rate of 2 gallons of Sinox and 10 pounds ammonium sulfate in 100 gallons of water, and applied at rate of 135 gallons per acre.
[2] Used at rate of 1 pint in 30 gallons of water.
[3] Made according to 3-3-100 formula.

The results given in table 6 show that treating the tubers with either a formaldehyde solution or weak Bordeaux reduced the amount of late-blight infection. The instant-dip treatments appeared to be as effective in controlling the late-blight decay as were the 5-minute treatments. Formaldehyde was somewhat more effective in controlling the decay than was Bordeaux and injured the freshly dug tubers to a less extent. The Bordeaux treatment caused some burning and darkening on the bruised areas of the potatoes.

DISCUSSION

The production of seed potatoes that are relatively free from the virus diseases and ring rot continues to be an important problem in Maine. This problem has been especially acute since 1937 when a serious epidemic of leafroll and other virus diseases occurred.

By early harvesting, one strain of Triumph and two strains of Green Mountain potatoes have been kept relatively free from diseases for a period of 9 years on Aroostook Farm in plots located near virus-diseased potatoes. Ring rot also was absent from these seed plots during this period. It is believed that more growers could and should produce their own seed potatoes by growing them on a well-cared-for isolated seed plot which is harvested early in the season before aphids have become abundant.

The time of maximum virus-disease spread varies for the different seasons with the dates of maximum aphid infestation. The results of the experiments show that during favorable seasons for aphids the newly formed tubers may become slightly infected with leafroll and mosaic by August 1 in northern Maine. During seasons not favorable for the development of aphids these diseases may not reach the tubers until the middle of August or later. The experiments reported here indicate that the spread of leafroll and mosaic can normally be controlled by harvesting the healthy tubers July 25 to about August 5.

Ring rot was absent from the experimental seed plots conducted by the writers and also from the commercial seed plots referred to in this paper. Ring rot is very often disseminated through the purchase and introduction of new seed stocks by the

farmers. Growers would avoid this danger if they produced ring-rot-free seed potatoes on their own farms or purchased them from growers who conduct an early-harvest seed plot.

The seed plot should be planted as early in the season as the weather conditions permit so that 1- to 4-ounce tubers will be produced by the first week of August when early harvesting must be done to insure healthy seed potatoes in seasons of heavy aphid infestation. It is a good plan to plant the seed pieces shallow and to cover them lightly so that they will emerge quickly.

The early-harvest seed-plot method is considered by many to be too costly and therefore impractical for use under the conditions in Maine. However, it now seems to be the only way by which good seed stocks can be raised in the concentrated potato areas of Maine, and the extra cost involved is more than offset by the lessened cost in roguing the seed plots and the assurance that the seed potatoes will be relatively free from the virus diseases when finally sold or planted in the commercial field.

Although some seed-potato growers on well isolated farms have controlled virus diseases without early harvesting, a number of these growers find that by early harvesting the seed potatoes for their isolated seed plots they have practically eliminated these diseases from their farms.

Some growers who have tested this method are so well satisfied with the results that they now plan to early-harvest enough seed stock each year to plant most of their commercial acreage as well as their seed plots. Furthermore, a few growers who have employed this method or a modification of it have produced the highest quality of seed potatoes for a continuous period, in some cases nearly 20 years.

Killing the potato tops by hand pulling is laborious and time-consuming. This practice, however, prevents at once the virus diseases from reaching the tubers, whereas killing the tops before harvesting by machine permits tuber infection to occur from the living stalks that persist for several days after the leaves have been killed. In the absence of late blight, or when the foliage and the blight spores have been killed with weed-killing products, harvesting by machine can be successfully practiced and the tubers may be dug a few days after the leaves have been killed by spraying.

Potato tops were killed satisfactorily by spraying them with the Sinox-ammonium sulfate mixture and the Handy Killer in

the concentrations recommended. A 6- to 7-per cent sulfuric acid solution also killed the plants rapidly but is dangerous to use and therefore has not been recommended for use by farmers in Maine.

The problem of killing potato tops is being studied further by the Maine Agricultural Experiment Station, and recommendations will be supplied when the information is available.

Late-blight tuber rot resulting from early digging can be greatly reduced by treating the freshly dug tubers in a formaldehyde solution or weak Bordeaux solution. Studies are being conducted further to find other suitable treating solutions that can be used at time of harvest to disinfect immature potatoes for seed purposes.

METHODS RECOMMENDED FOR SEED-POTATO GROWERS

Farmers who intend to raise seed potatoes by the early-harvest seed-plot method should follow a rather definite procedure.

It is necessary to have a modern seed plot. The best seed stock that is available should be used, and it should be planted as early in the season as the weather permits so that fairly large tubers will be formed by the first week of August when the crop is harvested. The seed plot should be planted by the tuber-unit method and generally it is preferable to leave a one-hill skip between each tuber unit. Good isolation is recommended, although, as has been shown, good seed potatoes can be produced under poor isolation, provided the seed potatoes are harvested early in the season.

The seed plot should be thoroughly rogued for the virus diseases as early as possible, care being taken that no diseased hills or units are missed and that all the seed pieces are removed from the soil along with the diseased tops and not allowed to grow again. The diseased plants should be dropped at once into an insect-proof bag and carried from the seed plot before they have wilted and the aphids have had a chance to leave the diseased tops and infect the healthy.

The early-harvesting method also involves killing the foliage of the healthy plants in the seed plot before the virus diseases have become widely disseminated. Experiments have shown that the

potato tops should be killed not later than the first week of August to insure the best success in obtaining good seed under the conditions of northern Maine.

A convenient method of pulling the tops is to press the prongs of a hand digger or potato hook on the soil over the hill and then pull the stems between the prongs so that the tubers become detached and remain in the soil.

More recently it was found to be more convenient to kill the tops and the late-blight fungus by spraying with certain chemicals before the crop was harvested by machine.

Harvesting by machine, while the foliage is green, is less laborious than pulling the tops by hand or spraying to kill the vines. This procedure, however, involves great risk of tuber infection and decay caused by the late-blight fungus.

The tubers in the early-harvested seed plot are immature when dug and therefore must be handled carefully to avoid bruising. Picking the tubers into boxes or crates and storing them in these containers prevents much bruising. Little decay occurred provided the potatoes were stored in a cool cellar or bin under farm conditions.

SUMMARY

The control of leafroll and mosaic continues to be an important problem for Maine potato growers.

Tubers were harvested from tuber-unit seed plots on successive dates to determine the time the crop should be harvested in order to prevent the spread of the virus diseases.

The extent of the spread of the virus diseases increased as the date of harvest was delayed, there being little disease in the seed stock harvested from July 25 to the first week of August and usually a considerable amount of disease if the seed plot was harvested late in the season. Tubers harvested by the first week of August in experimental plots were relatively free from leafroll, mosaic, and spindle tuber.

The date of harvesting may be delayed until the second week of August or even later with very little virus infection of the seed stock, provided aphids are few or are absent.

A strain of Triumph and two strains of Green Mountain potatoes were maintained relatively free from the virus diseases for 8 and 9 years, respectively, by being grown on Aroostook Farm in an experimental seed plot which was early harvested each year before aphids had become abundant.

The early-harvest seed-plot method was successfully employed with eight experimental seed plots located in different parts of Aroostook County, Maine.

The early-harvest seed-plot method is practical and a number of farmers have maintained high-quality seed potatoes by its use for a period of 10 to 20 years.

Ring rot was not found in any of the seed potatoes referred to in this bulletin.

Farmers are warned not to harvest their seed plots while the foliage is green if late blight is present.

Hand pulling is an effective method of killing the potato tops for the early-harvest seed plot. The method, however, is very tedious, time-consuming, and expensive.

Potato tops were successfully killed in the experiments discussed in this bulletin by spraying with a solution of Sinox (2 gallons) and ammonium sulfate (10 pounds) in 100 gallons of water, or with Handy Killer (sodium arsenite), 4 pints in 100 gallons of water.

Treating freshly dug tubers with a formaldehyde solution (1 pint in 30 gallons of water) or a weak Bordeaux (3-3-100) greatly reduced the amount of late-blight decay of tubers.

If every potato grower in potato-growing regions, such as Aroostook County, Maine, would practice early harvesting of seed potatoes, as described in this bulletin, it is believed that ring rot would be eliminated and that leafroll, mosaic, and other virus diseases could be controlled so that epidemics of virus diseases would be very much reduced, if not prevented.

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